between a variation in x and a corresponding variation in y. Let us suppose that all the ϵ's on which x depends, i. e., all the ϵ's for which the corresponding a's on the right-hand side of the first equation in (1) are not zero, are increased by a certain quantity d, whereas all the other ϵ's, i. e., all the ϵ's on which y depends but x does not depend remain constant. If we represent by x' the new value of x, and by y' the new value of y after the increase in the ϵ's, then when we take account of equations (7), (8), and (2) we have readily

$$\begin{aligned} y'-y &= (m-p-q)ad, \\ x'-x &= (m-p)ad. \end{aligned} \qquad (11)$$

Since the units in terms of which x and y are measured are in general arbitrary, it is apparent that we need to introduce some standard unit for each of them before we can attach any definite significance to a comparison of their changes in value. The natural way to choose a unit for this purpose is to relate its size in some definite way to the range of variability of the variable quantity concerned. This can be done by choosing as a unit the *standard deviation* of each variable. The standard deviations of the ϵ's, as stated above, are given by equation (6). The standard deviation of any other variable is defined in an analogous manner. Hence in view of equations (3), (4), (6), (7), (8), and (9), we have for the standard deviations of x and y

$$s_x=\sqrt{\frac{m-p}{n}}\,as, \quad s_y=\sqrt{\frac{m-q}{n}}\,as. \qquad (12)$$

R may be said to be a good measure of the closeness of relationship between the two variables since it measures the extent to which a *typical* change in one variable causes a corresponding change in the other variable. If now we set

$$R=\frac{(y'-y)/s_y}{(x'-x)/s_x}, \qquad (13)$$

we obtain from (11) and (12)

$$R=\frac{m-p-q}{\sqrt{(m-p)\,(m-q)}}.$$

Hence in this particular case $r=R$, and r may therefore be said to be a good measure of the degree of relationship between x and y.

It is easy to see, however, that cases may arise in which r and R differ considerably in value. Suppose, for example, that the a's of equation (2) satisfy the following conditions:

$$\begin{aligned} &a_{11}=a_{12}= \cdots a_{1p}=a_{2,m-p+1}= \cdots a_{2m}=0, \\ &a_{21}=a_{22}= \cdots a_{2p}=a_{1,m-p+1}= \cdots a_{1m}=10a, \\ &a_{i,p+1} \;= \cdots a_{i,p+2}= \cdots a_{i,m-p}=a. \quad (i=1, 2,), \\ &(m=102p) \end{aligned}$$

Then we find by substituting in formulæ (5) and (13) that

$$r=0.5, \quad R=0.9.$$

Under still other suppositions the discrepancy between the values of r and R may be still greater. Hence it is apparent that r may not always be a good measure of the closeness of relationship between two variable quantities.

The chief conclusion to be drawn from the foregoing discussion is to a considerable extent a negative one. It is shown that it is possible to state conditions under which the coefficient of correlation as calculated from equation (1) will furnish a reliable measure of the degree of relationship between two variable quantities. But it is also shown that in cases where these conditions are not approximately fulfilled, the coefficient of correlation will not necessarily be a good measure of this relationship. As there seems to be no way of determining in any particular case whether or not the conditions we have stated are satisfied, it is apparent that considerable caution should be observed in drawing definite inferences from the value of a coefficient of correlation.

RAINFALL IN CHINA, 1900–1911.[1]

By CO-CHING CHU, A. M.

[Dated: Cambridge, Mass., Mar. 21, 1916.]

INTRODUCTION.

As the fluctuation in rainfall from year to year is great, it is always a difficult matter to discuss the subject and draw isohyets with accuracy and intelligence unless we have a long series of reliable observations well distributed over the region under discussion.

China has been backward on all subjects meteorological. The data on rainfall in China are mostly spasmodic, inaccurate, and limited to recent years only. The data on rainfall in this article are based on Rev. Louis Froc's work "La Pluie en Chine, durant une period de onze années, 1900–1911," published by the Catholic Mission of Zi-ka-wei, Shanghai, China. These are, no doubt, the most recent and at the same time the most reliable data on the rainfall in China. In all, there are 88 stations, divided into four classes according to the length of the record of rainfall. In the first class, which comprises 34 stations, all except 4 have data extending through the period of 11 years. The records of the remaining stations are incomplete, varying in length from eight to two or three years. The stations are not very well distributed, but are concentrated mostly along the coast and the valley of the Yangtze River; in the northwest they are entirely wanting. The area of China proper, according to Mill's International Geography, is approximately 1,300,000 square miles. Assuming that all the data of the 88 stations were available and that they were uniformly distributed, there still would be only one station to every 1,500 square miles.

It is evident that a rainfall map based upon these data can only be tentative. If the stations were more numerous and better distributed, and if the records extended over a longer period, the map would be probably quite different from what it is.

RAINFALL CONTROLS.

In the main, there are three factors which control the amount and seasonal distribution of precipitation in China, (1) the monsoon, (2) the topography, and (3) the cyclonic distribution.

(1) *Monsoon.*—The monsoon[2] is a seasonal wind which is best developed in Asia, owing to the vastness of

[1] A study offered as part of the requirements for the degree of A. M. at Harvard University in 1915; prepared under the direction of Prof. A. G. McAdie and R. De C. Ward.

[2] Whether the summer southeast wind in China should be called "monsoon" or "trade wind" is controversial according to Mr. B. C. Wallis. See the extract from a paper by him, MONTHLY WEATHER REVIEW, January, 1915, 43:24.

that continent. The Siberian HIGH in winter and continental LOW in summer make eastern Asia specially favorable for the development of that wind.

Along the Chinese coast the wind is on-shore and wet in summer and offshore and dry in winter. The wet or southeast monsoon can be best appreciated in southern and central China along the coast. In Hongkong or even in Shanghai the summer wind is usually humid and heavily laden with moisture, which, coupled with high temperature, gives one an oppressive and "muggy" feeling. The dry or northwest monsoon is best developed in northern China, where the winter is unusually dry and dusty.

The following wind percentages along the Chinese coast are taken from the United States Hydrographic Office pilot chart for the year 1914–15.

TABLE 1.—*Percentages of the predominant winds along the Chinese coast.*

Month.	Yellow Sea.	Estuary of the Yangtze.	Formosa Channel.
January	N., 30; NW., 22	N., 35	NE., 55.
February	N., 25	N., 30	NE., 55.
March	NW., 18; N., 15	NE., 20	NE., 50.
April	SE., 18	SE., 22	NE., 35.
May	S., 25	SE., 28	NE., 40.
June	SE., 25; S., 20	SE., 30	SW., 28; NE., 20.
July	S., 25	S., 25; SE., 25	SW., 28; S., 18.
August	S., 15	SE., 25	SW., 18; NE., 18.
September	N., 20	NE., 28	NE., 40.
October	N., 25	NE., 30; N., 25	NE., 63.
November	N., 14	NW., 14; N., 12	NE., 60.
December	N., 32; NW., 25	NW., 25	NE., 55.

From the above table we see that the wind on the southern coast is much more steady than on either the northern or the central coast. From October to March the wind at Hongkong or its neighborhood is northeast 50 per cent of the time or more. Only in the three summer months is the prevalent wind from south or southwest. The north or northwest wind is almost nil in this part of the coast. The northeast wind is the regular Trade, which greatly decreases in strength along the central and northern coasts, while the northwest wind in winter and southeast in summer gradually increase in their percentages.

(2) *Topography.*—The topography [3] of China proper is quite mountainous. Roughly speaking, about 50 per cent of the country is above the 1-kilometer contour. Unlike the highlands in the United States, the Chinese highlands are in the form of plateaux and not in the form of mountains or ridges. In the south the coast is quite steep, while in northern and central China, owing to the delta of the Yellow River and the Yangtze, the coasts are usually low with the exception of the region near the Shantung Peninsula.

(3) *Cyclonic distribution.*—There are three main paths of cyclones: (*a*) Those storms which originate in Siberia, Mongolia, and Manchuria; (*b*) those which originate in China proper and Thibet; and (*c*) those which originate in Pacific Ocean, Eastern Sea, or Yellow Sea.

The data on the storm tracks contained in this article were taken from the meteorological reports published in Zi-ka-wei, Shanghai, for the years 1901–1910. The storms were studied individually and classified according to their origin. The Siberian storm usually originates west of Irkutsk, and travels east, crossing eastern Mongolia, southern Manchuria, and thence to northeastern China in Chi-li or Shantung; or more often from Manchuria directly enters the Japanese Sea and thence to Okhotsk Sea. The direction southeastward changes to northeastward, and the average time for the passage is about six days. These storms may also originate in Mongolia or Manchuria. The storms of the second group usually have their low centers first appear south of the Lake Tongting or in the Province of Szechuang, and arrive at the coast near Nanking on the second day, and leaving it on the third for the Eastern Sea, whence they go to Okhotsk Sea by way of the Japan Islands. The direction of the storm path on the continent is eastward. The centers of low pressure that originate in the Pacific are mostly what are known as typhoons or baguios. The storm track of this group has been extensively studied by Algué and others.[4] In winter the storms are usually far from the continental coast and exert little or no influence on the rainfall in China, while in summer and early autumn they bring the heaviest rainfall. The storms in summer develop near or east of the Philippine Islands, pass thence to eastern Chinese coast and northwestward over the Japanese Sea or Japan Islands toward Kamchatka. In the summer no storm track can be traced over Bering Sea and the extreme northeast Pacific coast.

The meteorological reports of Zi-ka-wei also contain the daily rainfall data of 41 stations in China for the years 1901–1908, and at 70 stations for the years 1909–1910. Some of the additional stations are Japanese stations. The number of storms recorded increases with years, and the location of the low centers is more clearly indicated in the later years, owing to the increase in the number of stations.

Some of the storms reported by the Zi-ka-wei Observatory are too far off in the ocean to affect the rainfall in China and a few pass too far north in Siberia. The following 626 storms, which passed across or near China proper, Manchuria, and the neighboring seas, were classified according to origin.

TABLE 2.—*Classification of 626 storms that passed across or near China.*

Month.	Siberian type.	China proper type.			Typhoons.		Total.
		North China.	South China.	Eastern Sea.	In ocean.	On coast.	
January	12	3	23	7	0	0	45
February	9	7	16	5	4	0	41
March	20	4	21	7	4	0	56
April	28	7	25	3	4	0	67
May	26	11	19	1	12	0	69
June	17	5	26	3	9	4	64
July	6	6	8	3	14	14	51
August	1	5	2	1	16	20	45
September	7	2	5	3	19	13	48
October	11	5	11	2	19	8	56
November	18	4	9	3	10	1	45
December	16	5	12	1	4	0	38
Total	171	64	177	39	115	60	626

The storms are well distributed as to the months. There are two maxima, one in spring and the other in late fall. The first is due to the frequency of the Siberian and China proper storms and the second to the great number of typhoons in the autumn. The velocity of these storms increases from summer to winter. For the storms of the first two types the velocity varies from 20 to 40 miles (9–18 m. p. s.) an hour in winter and from 15 to 25 miles (7–12 m. p. s.) an hour in summer. For the

[3] For a comprehensive description of the topography of China, see Mill's International Geography, chapter on China. The best topographic map is probably the one contained in L. Richarde's "Comprehensive Geography of China," Shanghai, 1907. See also the photographic reproduction of a German hypsometric map of China (given by Blackwelder) in Report of the Smithsonian Institution for the year ending June 30, 1913, Washington, 1914, p. 386.

[4] For tracks of typhoons, see among other works *Algué's* "Cyclones of the Far East," plate 40.

typhoon the hourly velocity averages about 20 miles (9 m. p. s.) in winter and about 18 miles (8 m. p. s.) in summer. The storms that originate in the Eastern and Yellow Seas are not typhoons, but belong to the second group, as can easily be seen by their monthly distribution.

MEAN ANNUAL RAINFALL.

There are three separate rainfall districts in China: *First*, north China, where the mean annual amounts to about 50 to 100 centimeters. As winter in north China is unusually dry, more than 60 per cent of the rain falls in the three summer months, when it is most needed for wheat, barley, and other important crops. The maximum comes in July or August and the minimum in February. *Second*, the Yangtze Valley, where the mean annual amount varies from 100 to 150 centimeters, decreasing very gradually from the coast inland. Here winter rainfall is more abundant than either in north or south China, although the amounts are small. The maxima for most of the stations come in July and the minima in December. The secondary minima in May, and the secondary maxima in January, are also typical. The *third* district is south China, where the mean annual fall is 150 to 200 centimeters along the coast and 100 to 150 centimeters at the inland stations. The percentages of rainfall in summer here again increase. The maxima come usually in June, but sometimes in August.

FIG. 1.—Mean annual rainfall of China (centimeters).

Besides these three divisions, the island stations need to be grouped separately. It has been pointed out by Supan [5] that the rainfall on the islands along the Chinese coast, instead of exceeding that on the continent, actually decreases. The islands have a lower mean annual fall than have the continental stations on the same latitude, and this is specially true in the south.

[5] See Hann, Klimatologie, 1911, v. 3, p. 305.

TABLE 3.—*Chinese stations used in the present study, with annual rainfall reduced to the period 1900–1911.*

Station.	Latitude (North).	Longitude (East).	Altitude.	Mean annual rainfall.	Length of record.
NORTH CHINA:	° ′	° ′	*Meters.*	*Mm.*	*Years.*
Aigun	49 50	127 38	136	432.5	9*
Harben	45 46	126 50	147	564.0	9
Mukden	41 48	123 23	44	598.2	6
Newchwang	40 41	122 16	3	638.2	8½
Chemulpo	37 29	126 32	14	952.4	11
Chefoo	37 33	121 22	3	587.8	11
Tsingtau (Kiaochow)	36 04	120 19	79	718.2	11
Tamingfu	36 18	115 18	(?)	580.8	11*
CENTRAL CHINA:					
Ningpo	29 57	121 45	10	1,331.0	11
Shanghai	31 12	121 26	7	1,161.2	11
Chenkiang	32 13	119 25	12	1,118.6	11
Wuhu	31 20	118 20	15	1,300.7	11
Kiukiang	29 45	116 08	20	1,610.3	11
Hwohkiu	32 22	116 15	(?)	1,010.6	11*
Hankow	30 35	114 17	36	1,112.7	11
Ichang	30 42	111 16	51.5	1,035.8	11
Chungking	29 34	106 31	230	1,024.9	11
Yunnanfu	25 04	102 49	1,980	1,098.5	8
Chengtu	30 40	104 03	518	881.5	11*
SOUTH CHINA, COAST:					
Wenchow	28 01	120 40	3	1,558.4	11
Foochow	25 58	119 27	20	1,514.6	11
Amoy	24 27	118 05	4	1,175.7	11
Swatow	23 23	116 40	4	1,509.5	11
Shanshui	23 06	112 53	10	1,757.9	11
Hongkong	22 18	114 10	32	2,034.7	11
Pakhoi	21 29	109 07	5	1,985.5	11
SOUTH CHINA, INTERIOR:					
Wuchow	23 29	111 20	2	1,339.8	11
Nanning	22 42	108 03	122	1,110.1	11
Lungchow	22 22	106 45	(?)	1,994.3	11
ISLAND STATIONS:					
Shantung Cap	36 54	122 32	12	725.3	11
Chawei Shan	31 25	122 14	53	989.4	11
Gutzlaff	30 49	122 10	75	1,078.0	11
North Saddle	30 52	122 40	72	1,020.0	11
Steep Island	30 13	122 35	63	914.0	10
Peiyushan	28 53	122 16	82	1,127.9	7
Tongyong	26 33	122 30	111	799.3	6
Middle Dog	25 58	119 59	59	1,181.7	7
Turnabout	25 26	119 56	65	996.9	11
Okseu	25 00	119 17	62.5	844.1	11
Chapel Island	24 10	118 20	55	1,035.0	11
Pescadores	23 30	119 45	11	1,024.5	(?)
Lamocks	23 16	117 17	58	1,079.4	11
Tainan	22 45	120 15	9	1,676.6	(?)
Kelung	25 15	121 45	(?)	3,422.8	(?)

In all there are 44 stations. Most of them have records for the whole period of 11 years. Those marked with an * in the last column have records for less than 11 years, but they have been reduced to this period by comparison with a neighboring station of longer record. The method of reduction has been as follows: Suppose that station A has an incomplete record, let x be its mean annual rainfall for the observed period. Call the neighboring station with a record for the whole 11 years station B and let R be the mean annual rainfall of B for the whole 11 years, while S is the mean annual rainfall of B for the years corresponding to the record at A. If we call y the mean annual rainfall of A for the 11 years, then

$$y = R\frac{x}{S}.$$

The accuracy of the mean corrected annual rainfall, ascertained in this manner, depends upon both the distance and the difference of altitude between the two stations A and B. The incomplete records of some of the isolated stations have to be left uncorrected.

Of the 8 northern stations only 3 have complete records. Among the 11 stations along the Yangtze, 8 stations have complete records; and all 10 of the southern stations are complete. Among the island stations 3 records, taken from the Journal of the Meteorological Society of Japan for 1915, are of unknown period.

TABLE 4.—*Monthly percentages for the composite stations.*[6]

Month.	North China (3 stations).	Central China (4 stations).	South China (4 stations).
	Per cent.	*Per cent.*	*Per cent.*
January	1.5	6.1	2.5
February	0.8	4.1	4.2
March	2.4	8.3	6.1
April	4.5	10.7	9.4
May	7.5	8.4	11.5
June	11.1	14.9	16.0
July	26.4	16.0	12.2
August	24.6	11.0	14.0
September	9.7	7.1	12.6
October	5.5	6.9	5.4
November	3.0	3.5	2.9
December	3.1	2.9	2.8

The records of north China are taken from the three stations Newchwang, Chefoo, and Tsingtau; those of central China from the following four stations: Shanghai, Chenkiang, Wuhu, and Kiukiang; and those of south China taken from the four stations Wenchow, Foochow, Swatow, and Hongkong.

The predominant influence of the monsoon is plainly seen in the decrease of precipitation from south to north, and the marked summer maxima. Exceptions are to be found to the first statement, but they can be explained as due to the topographical or other local causes. Thus, the mean annual amount at Chefoo is distinctly less than that at Tsingtau, although they are only a little distance apart. The difference is owing to the rugged mountains in the Shantung Peninsula, which has an elevation of about 1,800 meters at its highest point. Since the wind is northerly in winter and southerly in summer, and since precipitation comes mostly with the southerly wind, the result is that in both summer and spring Tsingtau has more rainfall, and only in winter, the dry months, does Chefoo receive more precipitation. The difference between the mean annual falls is more than 12 centimeters.

The Yangtze stations in Table 3 are arranged according to the longitude. The uniformity of distribution along the valley of the Yangtze is noteworthy. The difference in precipitation between Shanghai, on the coast, and Chentu, which is more than 1,500 miles from it and approximately at the same latitude, is only 28 centimeters. Hence, the isohyets along the Yangtze are almost parallel to the latitudes, and the gradient is very small compared with that on the southern coast. This is probably due to the fact that while the elevation of land along the Yangtze is gradual the slope of the southern coast is much steeper.

As stated before, the mean annual amount decreases from south to north. As a whole this is true, but on the southern coast we find a notable exception in the case of Amoy. The deficiency of precipitation in the region around Amoy can be seen plainly on the mean annual map (fig. 1). The probable explanation is to be found in the rain-shadow effect caused by the high mountains in eastern Formosa. Indeed, that effect is more marked on the islands in Formosa Strait and on the stations on the western coast of Formosa itself. Thus, while Kelung situated at the northeast of the mountain, has a mean annual of 342 centimeters, Tainan on the western side of it, has a little less than half that amount and the island stations in Formosa Strait less than a third. The deficiency is more marked in Amoy than in Foochow or Swatow, partly because Amoy is almost at the center of the rain shadow and partly because there are some hills around Amoy.

All the 44 stations have the maximum in summer, with the exception of Kelung, on the east coast of Formosa, where the maximum comes in late autumn or winter. The maxima in northern China, as already pointed out, occur about a month later than those in southern China. The minima of the northern stations come also late in February. Without a single exception, among the lower Yangtze stations up to Hankow, there is a decrease of rainfall in the month of May. On the coast from Ningpo to Hongkong, with the exception of Amoy and Swatow, which are unduly influenced by the rain shadow effect of Formosa, the mean monthly amount for July is distinctly less than either that of June or August. This latter fact has been pointed out by Julius Hann in his Climatology.[7]

The July minimum was long known to the Chinese living in the south; but they described it as two maxima, one in early summer [8] and one in late summer. Baron von Richthofen in his letter on the Provinces of Chekiang and Nghanhwei, also mentioned the fact that while he was traveling in southern part of Chekiang in the month of July he was not seriously detained by rain, which was a great advantage over the traveling in the northern Provinces at that period.

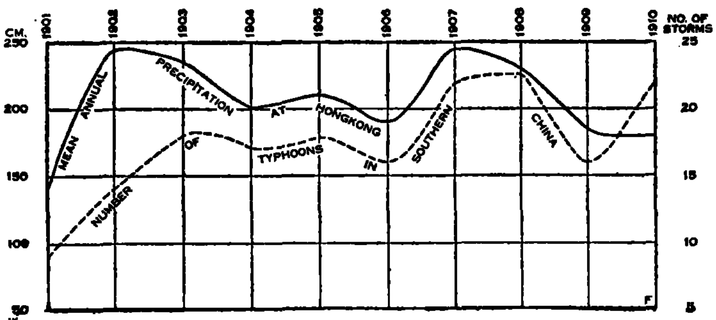

FIG. 2.—Annual march of precipitation at Hongkong compared with the annual numbers of typhoons over southern China (1901–1910).

The July minimum along the southern coast can be explained, at least in part, by the wind direction. The following percentages of wind direction were taken from the pilot chart of United States Hydrographic Office. From Table 5 a comparison between the wind directions in the months of June, July, and August can be made.

TABLE 5.—*Percentages of wind directions along the southern Chinese coast.*

Month.	NE.	E.	SE.	S.	SW.	W.	Wet.	Dry.
June	20	12	12	18	26	0?	62	26
July	12	13	12	17	26	9	54	35
August	18	12	13	13	18	0?	56	18

Under the column "Wet" are included winds from northeast, east, southeast, and south; and under the column "Dry" are included winds from west and southwest. The sum total of percentages of each month is not 100, owing to certain directions not shown in the chart.

[6] Hann, op. cit., vol. 3, p. 304.

[7] *Hann*, op. cit., v. 3, p. 305.

[8] The early-summer rain of southern China is also known as the "season of the plum rain," as was pointed out by Prof. *T. Okada* in his paper, "The rainfall of China and Korea," this REVIEW, November, 1905, 33:479 (Jour., metl. soc. Japan, Sept., 1905).

The relatively high percentages of precipitation in central China in winter is probably due to the storms of the second group, which usually travel along the valley of the Yangtze. By examining the table of storm frequency (Table 2) we see that the Siberian and the China-proper types of storms all have their maxima in winter and spring. A further inspection of the daily rainfall data reveals the fact that the Siberian storms usually give only cloudiness in northern China, although causing precipitation in the Japanese Islands. The storms of the second group, however, usually give rise to rainfall, specially when they take the Yangtze route. When this type of storm travels along the valley of Yellow River, the precipitation is usually light.

South China from Foochow and Yunnanfu southward is rarely affected by the storms of the first or second groups. The rainfall in this region mostly comes with a typhoon. In order to see whether there is any correlation between the number of typhoons and the mean annual rainfall of south China, curves of the number of storms in the 10 years 1901–1910 and the mean annual rainfall of Hongkong were plotted in the diagram, figure 2. There is some resemblance between the two curves, although it is not very close.

To determine the storm type and its relation to rainfall and cloudiness, six storms were chosen, one each to represent Siberian, Mongolian, south and north China, and the coast and ocean typhoons. The tracks of these LOWS were drawn on the map presented in figure 3. These storms are, in general, representative of their respective types. They are all taken from the last two years in order to have the data of the accompanying daily rainfalls more complete.

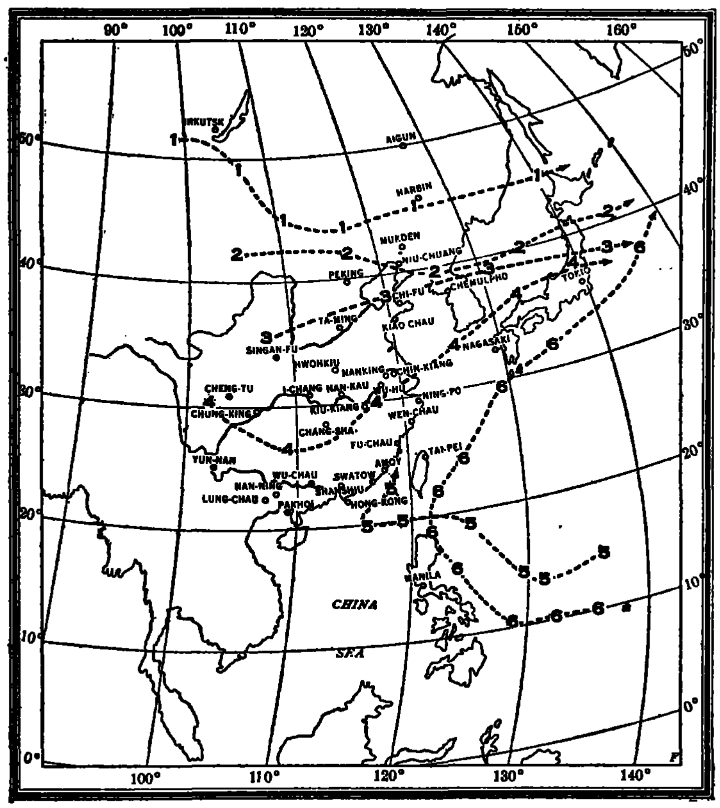

FIG. 3.—Typical tracks of storms of different origins crossing China and Japan.

The successive 24-hour a. m. positions of the storms are indicated by the locations of the respective figures, 1, 2, 3, etc. The types and their respective dates are as follows:
1= Siberia type, January 2–7, 1910.
2= Mongolia type, April 1–5, 1910.
3= North China type, May 31–June 3, 1910.
4= Yangtze Valley type, June 11–16, 1910.
5= Coast typhoon, October 14–20, 1909.
6= Ocean typhoon, May 3–12, 1910.

The amounts of rainfall recorded at different stations during each storm are taken from the Zi-ka-wei Observatory reports; the figures given are as follows:

Storm No. 1, Siberia type, January 2–7, 1910; with the exception of Mukden, where the amount was 1.8 millimeters on January 4, 1910, there was no precipitation in China. In Japan, on the 8th, Tokyo received 2.4 millimeters, and several other Japanese stations recorded light rainfall.

Storm No. 2, Mongolia type, April 1–5, 1910; on April 3, 1910, Newchwang received 3.8 millimeters, Takou 1.0 millimeter; the rest of the northern Chinese stations had clear weather; while Nemuro (lat. 43°N., long. 145°E.) on the 5th had 18.9 millimeters.

Storm No. 3, North China type, May 31–June 3, 1910; in north China, Chefoo had 54 millimeters on June 1, 1910, and Newchwang had 37 millimeters as the total of three days. The rest of the northern stations all had light rain, while the Yangtze and southern stations were all clear. Tokyo received 50 millimeters.

Storm No. 4, Yangtze Valley type, June 11–16, 1910; of the northern stations Newchwang had 1.3 millimeters, Tientsin 32.5, Chefoo 30, and Tamingfu 106. Of the central China stations the total amount received was: Chungking 3.0, Ichang 47.5, Chentu 0.0, Hankow 144.0, Shanghai 166.5, and Ningpo 51.4. Of the southern stations, Wenchow had 7.9 millimeters, Foochow 10.3, Amoy and Swatow had no precipitation, Hongkong had 2.3. In Japan, Tokyo received 50 and Nagasaki 232 millimeters.

Storm No. 5, Coast typhoon, October 14–20, 1909; the stations which had precipitations were Foochow with 50 millimeters, Amoy 48, Swatow 20.4, Hongkong 327.2, Shanshu 192.6, and Wuchow 43.2. Pakhoi and Lungchow had none.

Storm No. 6, Ocean typhoon, May 3–12, 1910; this particular typhoon had no effect on southern China. The central Chinese coast was cloudy.

FIG. 4.—Rainfall isomers for China for the three summer months (1900–1911).

In general, we can say that with the exception of storms belonging to Type No. 5, which disappear while on the continent, those of the remaining five types converge upon the northern Japanese islands and then disappear over the Pacific; some can be traced even to the Pacific coast of North America.

Types 1 and 2 give very little rainfall, and Type 3 only light rainfall in northern China and no effect at all in central or southern China. Type 4 gives quite heavy rainfall at lower Yangtze stations, but only light rainfall over the upper Yangtze region, the southern, and the northern coast. Type 5 is the heaviest rain bringer to southern China, but it has little effect in central China and the LOW seldom goes up to Shantung. No. 6 has but little influence on the precipitation of China, and usually comes in winter.

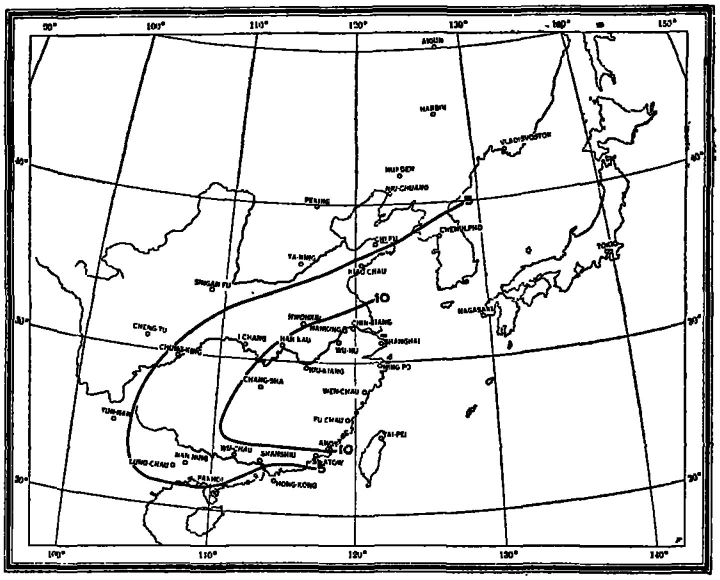

FIG. 5.—Rainfall isomers for China for the three winter months (1900-1911).

The stations Foochow, Amoy, and Swatow are so unfavorably situated that they receive only light rainfall during the storms of Types 4 and 5 when there is heavy rain to the north and south of them. This causes a deficiency of precipitation at those stations and they receive less than their position would seem to entitle them to.

Tornadoes.—There was only one tornado throughout the whole period, and that was in 1902 in Shantung.

ABSOLUTE DAILY AND MONTHLY MAXIMA, AND SNOWFALLS.

Pakhoi, the southernmost station, has the distinction of having the highest extreme annual, monthly, and daily maxima. These occurred in three different years. The extreme annual maximum is 2,691.3 millimeters, or about 100 inches. Such amount is of common occurrence in the United States, specially on the high mountains of the Northwest. The extreme monthly maximum at Pakhoi occurred in July, 1900, and the amount is 952.9 millimeters; and the daily maximum occurred June 27, 1903, the amount being 319.5 millimeters, or about 13 inches. The maximum daily rainfall in the United States is about 20 to 25 inches and the maximum monthly rainfall about 71 inches,[9] considerably more than those recorded in China. This no doubt is due to the longer record which is to be obtained in the United States.

Along the southern coast in Hongkong and Pakhoi and their neighborhood more than half of the mean annual fall comes in the three summer months, June, July, and August. In central China, south of the Yangtze, the percentage for the same three months is smaller, about 40, while in the region north of Yellow River more than 60 per cent of the mean annual comes in these three months. This is of much importance to north China, since the rainfall in this part of the country is light—about 750 millimeters, or 30 inches—and as winter in north China is very cold. If a large portion of the precipitation should come in winter it would be in the form of snow, and hence be of little use to the farmers.

The percentages in the three winter months—December, January, and February—vary from 15 per cent in central China along the coast to about 1.5 per cent in Mukden. In northern China the precipitation in these three months all comes in the form of snow, while in central China the precipitation partly consists of rain. In the month of January, Pekin is a little colder than Boston. It has a monthly mean of 24°F., or 268.3°A., while in central China, Shanghai has a monthly mean of 37.2°F., or 276.1°A., in January. At Ningpo or even a little south we have snow every year, probably five or six times annually, while at Canton or Hongkong snow is rare.

[9] For some maximum daily and monthly rainfalls in the United States see McAdie's "Climatology of California," Washington, 1903. (Weather Bureau bulletin L), pp. 171-172.

AMERICAN DEFINITION OF "SLEET."

By CLEVELAND ABBE, Jr.

[Dated: Weather Bureau, June 30, 1916.]

In undertaking to collect and discuss American statistics of the occurrence and the amount of ice coating or "glaze" (a term just adopted for the coating) deposited on electric transmission and other lines, the Weather Bureau had forced on its attention the prevailing diversity in the use of the terms "sleet," "ice storm," "glazed frost," "silver thaw," "glare ice," etc. As the phenomena bearing these names are all more or less of public interest, it is very necessary that our names for them shall be clearly defined and as specific as possible in application. The chief difficulty met with seems to be the prevailing uses of the word "sleet"; accordingly, on January 6, 1916, the Chief of the Weather Bureau appointed a "committee to formulate suggestions of an appropriate nomenclature of sleet * * *."[1]

The committee thus appointed considered the subject from the five points of view: (1) Etymology of the word "sleet"; (2) early definitions; (3) modern definitions; (4) meteorological usage; (5) Weather Bureau usage. It will be convenient to discuss the committee's report in this manner.

1. ETYMOLOGY.

The word "sleet" is of uncertain derivation. Murray in the New English Dictionary, finds that it probably represents the Old English (Anglian) *slét* (which was phonetically derived from *sléatj*) and is related to the Middle Low German word *slôte* (LG. slôte, slate), Middle High German *slôze*, *slôz* and German *schlosse*, which mean "hail." Murray goes on to say that the Norwegian dialectal *sletta*, the Danish *slud*, and the Icelandic *slydda* have the sense of "sleet," but that it is difficult to associate any of these phonetically with the English word. (These Scandinavian words seem to mean "splash" or "slap"; and thus suggest the action which is repeatedly associated with *slét* in the early English authorities quoted by Murray. This significance will be recalled later in connection with usage.)

The committee sent out a large number of requests for information on this subject, but nothing in addition to the above derivations was received in reply.

[1] The members of the committee were Prof. H. C. Frankenfield (chairman), Prof. C. Fitzhugh Talman, Mr. P. C. Day, and Cleveland Abbe, jr.